THE USE OF RAMUS BONE CORES FOR MAXILLARY SINUS BONE GRAFTING: A SURGICAL TECHNIQUE

Erwin A. Crawford, DDS

The study describes a surgical technique for the use of Ramus bone cores routinely used in the surgical rebuilding of deficient maxillary sinuses. The bone core harvest is predictable and without significant morbidity to the patient. There is clinical evidence to suggest this technique may significantly speed up the process of building load-bearing bone with mechanical stability, allowing for earlier implant placement in strong bone.

Autogenous bone grafts have been fully explored in the literature regarding their efficacy and value in oral and maxillofacial reconstruction. In fact, by many, autogenous bone is considered the gold standard in reconstruction efforts. Many materials have successfully been used in sinus reconstruction. These include autografts, alloplasts, xenografts, and allogenic derivations. Autogenous bone remains the top choice for predictable grafting. The use of ramus bone cores for maxillary sinus grafting is predictable and offers a good source of autograft that is readily accessible. The harvest is routine and easy, with minimum morbidity. The third molar region is easily accessible and a familiar region for those that remove third molars on a regular basis.

Local bone grafts from the maxillofacial region have a distinct advantage of proximity between donor and recipient site. This reduces time and morbidity compared with extra oral donor sites. The mandibular ramus donor site has been demonstrated to be effective and predictable in growing good load-bearing bone for implant placement. The maxillary sinus offers a unique bone-growing area that has been predictable with many techniques. The literature is full of references to intraoral bone being used in the sinus. The real challenge is to grow load-bearing dense bone of sufficient quality in a short period of time that will allow for implant placement and retention under load. The ramus bone core surgical technique for maxillary sinus bone grafting needs to be considered. This technique for adding autogenous bone to the sinus offers another choice for autogenous bone harvest. The added advantages of ramus cores include local availability, quantity...
of donor bone, and low morbidity to the patient. These benefits allow ramus bone cores to be a first-line choice in autogenous sinus augmentation materials.

**Surgical Technique**

A panographic radiograph of well-delineated sinus morphology is the minimum for diagnosis. The use of CT scan imaging and software to predict the overall size and shape of the sinus can be useful. The use of a well mapped out panographic radiograph has been very effective for locating the sinus cavity and its limits. The panoramic radiograph is adequate for sinus augmentation and should be used. Sinus evaluation and patient selection is key in successful sinus augmentation. The Tatum lateral side grafting approach window and use of a layering technique for sinus augmentation will be discussed.

**Ramus Bone Core Harvest**

The retromolar pad, the external oblique ridge, and the retromolar triangle are all visualized and palpated before surgery begins. A full thickness incision is made starting 1 cm lateral and superior to the retromolar pad (Figure 5). The incision continues anteriorly and makes a 45-degree turn through the lateral one third of the retromolar pad. If teeth are present, one proceeds anteriorly around the facial sulcus of the teeth. If the patient is edentulous, then a midcrestal incision is made to the first premolar position.

A full-thickness mucoperiosteal flap is elevated to expose the lateral body of the mandible, the retromolar area of bone, and the external oblique ridge of the ascending ramus (Figure 6). The inferior lateral head of the temporalis muscle insertion around the coronoid process should be visualized. This is
FIGURE 9. Simple elevation of cores is accomplished with a 77R elevator.

FIGURE 10. After elevation is completed, the bone cores are removed with forceps.

FIGURE 11. The bone cores are briefly stored in sterile saline.

FIGURE 12. View of the donor site after removal of bone cores. No attempt is made to remove additional bone.

the superior extent of the reflection. The masseter muscle is reflected to expose the lateral body of the ramus. One continues anteriorly to expose the lateral aspect of the body of the mandible down toward the insertion of the buccinator muscle. The mental foramen can be exposed to gain visual coordinates on the location of the mandibular canal when the harvest of bone is more extensive.

A 6-mm trephine burr is used to outline the cores to be harvested (Figure 7). This is accomplished by drilling through the outer cortical bone (Figure 8). The trephine burr is placed lateral and parallel to the occlusal plane. From this location, harvesting may be performed anteriorly into the body of the mandible and/or posteriorly up the ascending ramus on the external oblique ridge. There is usually enough bone for at least two cores and up to six cores per ramus.

The drill should be positioned laterally so that it is just inside the outer cortical plate. When the mandible is narrow, it becomes necessary to include the outer cortical plate as part of the harvest. This will leave a three-wall defect as opposed to the ideal four-wall defect in a wider mandible. It is useful to overlap the osteotomies (Figure 8). This facilitates easy retrieval with an elevator since it provides space for an elevator between the cores.

Once all the sites have been planned, the drilling is continued through the cortical plate 2–3 mm. This minimal 2–3-mm extension beyond the cortical plate allows for safety. Ramus bone cores are principally designed to be cortical, with minimum cancellous harvest. It is not necessary to increase risk and try to harvest additional cancellous bone. The minimal extension allows for safety, staying clear from the mandibular canal. It is important to keep a finger rest while extending through the cortical plate in order not to blindly gouge through the medullary space without being able to visualize the mandibular nerve. If there is uncertainty about the position of the nerve, it is acceptable to just go through cortical plate and produce a 100% cortical core.

The overlapped circles of bone cores (Figure 8) are then delivered with a 77R elevator or similar elevating instrument (Figures 9, 10). The bone cores are stored in sterile saline, briefly, for use in the sinus graft (Figure 11). The
recipient site is inspected and no attempt is made to retrieve additional cancellous bone (Figure 12). This respects the limits of the mandibular nerve and lessens the chance for nerve injury. Closure is accomplished with 3-0 chromic suture in individual pattern.

**Sinus Surgical Protocol Using Ramus Cores**

**Introduction**

Appropriate planning about the size and volume of the sinus is mandatory. It is helpful to have a lateral sinus window mapped out before going into surgery, with landmarks and measurements to guide in the surgical process. The use of technology in the form of computed tomography (CT) scans and panographic radiographs has already been discussed regarding their relative value.

The classical lateral sinus approach of Tatum is used for the ramus core technique. The Sinus Consensus Conference of 1996, as reported in the Journal of Maxillofacial Implants, serves as a broad guideline to all sinus augmentation procedures. The literature makes definite reference to intraoral bone being used in the sinus graft. This report on technique will use ramus bone cores intact as a routine autogenous source and will describe a methodology for use in sinus grafting.

**Surgical technique sinus grafting with ramus bone cores**

A full thickness crestal incision is made in the posterior maxilla with appropriate vertical releasing cuts in the anterior. If teeth are present, then sulcular incisions are made and the facial tissue is fully reflected. The anterior release incision is best made 5 mm anterior to the anticipated most anterior border of the sinus window. This allows for full mucoperiosteal coverage over the grafted window at time of closure. The tissue is fully reflected superiorly and may be tied back to the buccal mucosa with 2-0 silk sutures.

A no. 6 carbide surgical round bur is used to mark out the landmarks (partial thickness osteotomies on the lateral bony surface of the sinus). These are usually the following points: the most anterior point, the most superior point, the most inferior point, and any other bony or tooth landmark. These data are transferred from the preoperative diagnosis of appropriate films and other sinus mapping technology. These will translate nicely to facilitate an appropriate sized window within the limits of the sinus. The points are joined with the carbide burr to produce a lateral window outline that scores the lateral surface of the antrum. The overall size of the window should only be large enough to adequately place graft materials and visually manipulate the membrane. The surgical burr is used in a lateral fashion to abrade the surface bone on the antrum until a bluish outline is observed (the bluish outline is that of the sinus membrane). The sinus wall is then infracted in a green stick fashion while keeping the membrane intact.

Sinus curettes are used to release the membrane 360 degrees along the outer edges of the window. The bony window is pushed in medially and rotated superiorly as the surgeon views the inferior floor, the anterior limit of the sinus, and the medial wall (Figure 13). It is sometimes useful to use dense HA as surface area technology to help in the process of rotating the window superiorly and medial. The idea of layering is well defined by Misch.

Autogenous bone can be harvested from many intraoral sources. The symphysis, tuberosity, osteotomy sites, osteoplasties, bone traps, and bone shavings can be harvested from any viable cortical area within the oral cavity. The ramus bone core technique focus is on maximizing volume of a cortical component with relatively easy harvest.

The ramus bone core technique uses many cores as possible to maximize the autogenous component of the graft (Figure 14). A Xenoplast is used in the upper and remote areas of the sinus window (Figure 15). Space is left open on the floor of the sinus over the proposed implant sites for the harvested cores. The ramus bone cores are then removed from saline and placed along the sinus floor and stacked on each other if the volume of the autogenous component is great. These cores are placed intact (not crushed or modified with intent) along the sinus floor. The orientation of the cores is so the cortical plate side is to the lateral along the floor of the antrum (Figure 16). They are placed in close adaptation over the proposed implant sites (Figure 17).

The cores are placed into the antrum noncrushed with intent. They are placed as 6-mm cores intact. There is good evidence to suggest that leaving that cortical component intact allows for that graft to maintain its size and quality as it undergoes transformation into the host bone as a new sinus constituent. Fonseca et al and Dado and Isquierdo report that, although the graft may be recontoured to better adapt to the recipient site, it should not be particulated or milled into finer pieces. Autologous bone graft studies have shown that smaller particles reabsorb more quickly and completely than larger graft particles.

Once the ramus cores are in place, more Xenoplast can be packed in, around, and over the cores to keep them relatively tightly packed along the sinus floor. The Xenoplast superior stabilizes the cortical autogenous component and also provides for osteoconduction. The difference from preoperative to postoperative radiographic views of the volume of dense graft material is quite substantial (Figures 18, 19). Closure is accomplished with interrupted sutures.

**Advantages of Ramus Bone Core Technique**

1. Autogenous bone has always been the gold standard for grafting and will likely continue to be. The use of good quality autograft reduces concerns over safety and efficacy of the graft material over time.
(2) The ramus as a donor site has low morbidity and risk compared with other areas.

(3) The cores are easily obtained (third molar area is familiar territory) and harvest is expedient (5–10 minutes).

(4) The quality of the autograft is desirable D1, D2, type 1, type 2 (this translates into better quality of bone for incorporation by creeping substitution into the sinus graft and the chance for spot welds via the core with the particulate alloplast to the host bone).23

(5) The donor site heals with few observed complications.

(6) The possibility of earlier reentry for implant placement has been observed, especially with greater than 5 mm of host bone below the inferior portion of the sinus. The use of ramus cores may well allow for early bridging of all sinus graft materials.23 The initial quality and size of the bone core, which maintains itself by not resorbing22,23 allows for good mechanical stability earlier in the healing sequence in the following ways:

- implant placement can occur from 4 to 6 months postgraft,14,24-26
- perception of bone quality from the implant osteotomy preparation is that of D2, D3 type 2 or type 3, or bone,
- all implants placed achieve excellent initial mechanical stability,
- radiographic evidence shows maintenance of the graft cores (Figure 20).

DISCUSSION

The technique of using the ramus as a primary source for bone grafting cores has many advantages. The ease of harvest, low site morbidity, bone quality, remote location, same side as sinus surgery, and the fact that cores realize a maintainable volume of cortical-cana-
cellous autograft all lend to the validity of routine use.

Ramus cores are inherently a good quality of bone. Due to the fact that they are not crushed, they maintain their volume and quality while undergoing transformation into host bone. Mandibular bone grafts, which are primarily cortical in nature, exhibit little volume loss and show good incorporation with short healing times.

The fact that implant placement is possible in the 4–6 month window accelerates restoration of the patient. Nonautogenous bone substitutes must be converted into load-bearing bone, and this process can take a great deal of time.

One of the crucial elements in successful sinus augmentation is for the grafted site to become a load-bearing entity of high quality bone so that the site maintains itself around loaded implants.

Cores can act as islands for bone growth and the fact that they are initially mechanically sound allows for earlier implant placement. This early placement of implants can have a stimulating effect on the bone and will serve to maintain graft volume and prevent loss during the remodeling stages. The use of primarily cortical grafts has been well demonstrated to be effective and load bearing within 4–6 months in virtually all situations within the oral cavity when used as a veneer and when closely adapted and secured to host bone with a good blood supply and tissue coverage. This overall quality of bone might well serve to improve stress transmission upon loading.

The harvest of ramus bone cores requires a practicing knowledge of the ramus and the mandibular nerve morphology. The harvest is one that is well within the skills of a knowledgeable surgeon familiar with the posterior mandible and the third molar and ramus region.

Conclusions
The use of ramus bone cores is an excellent source of cortico-cancellous autograft. The ramus, as a donor site, has demonstrated its clinical effectiveness in providing cortical grafts for onlay and block grafting. The ramus bone core technique further utilizes this autogenous source for predictable sinus bone grafting. There is ample clinical evidence to suggest the maintenance and success of this technique. As of July 2000, over 25 sinuses have been treated with this method. Implants have been placed as early as 4 months and as late as 9 months. In all cases, implant placement has been accomplished with good, sound initial stability. The routine use of ramus cores in the maxillary sinus may increase both graft bone quality over time and shorten the healing period. Further study and histomorphometric analysis is needed to demonstrate scientifically why an observed clinical technique produces continued predictable good quality bone at time of early implant placement. The mandibular ramus remains a safe, easy, viable source of autogenous bone cores that can significantly add to the quality of sinus grafts and may be considered on a routine basis.

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